

WHAT IS CLAIMED IS:

1. A nonvolatile magnetic memory device comprising;
 - 5 (A) a transistor for selection which is formed in a semiconductor substrate,
 - (B) a lower insulating interlayer which covers the transistor for selection,
 - (C) a first connecting hole which is formed in 10 a first opening portion made through the lower insulating interlayer and is connected to the transistor for selection,
 - (D) a first wiring which is formed on the lower insulating interlayer, is composed of an electrically 15 conductive layer, and extends in a first direction,
 - (E) a tunnel magnetoresistance device which is formed on the first wiring through an insulating film, and has a stacking structure formed of a first ferromagnetic layer, a tunnel barrier and a second 20 ferromagnetic layer which are positioned in this order from below,
 - (F) an upper insulating interlayer which covers the tunnel magnetoresistance device, the lower insulating interlayer and an extending portion of the 25 first wiring, and
 - (G) a second wiring which is formed on the upper insulating interlayer, is electrically connected to the top surface of the tunnel magnetoresistance device, and extends in a second direction different from 30 the first direction,
- in which a lower surface of the tunnel magnetoresistance device is electrically connected to the first connecting hole through a second connecting hole which is formed in a second opening portion made 35 through at least the insulating film and the first wiring and is electrically insulated from the first wiring, and

the tunnel magnetoresistance device, the insulating film and the first wiring have nearly the same widths along the second direction.

5 2. The nonvolatile magnetic memory device according to claim 1, in which said first wiring comprises a first high-permeability material layer and said electrically conductive layer which are positioned in this order from below,

10 a sidewall made of an insulating material is formed on each side surface of said tunnel magnetoresistance device, said insulating film and said first wiring along the first direction, and

15 the sidewall is covered with a second high-permeability material layer.

3. The nonvolatile magnetic memory device according to claim 1, in which said first wiring comprises a first high-permeability material layer and
20 said electrically conductive layer which are positioned in this order from below,

a first sidewall made of an insulating material is formed on each side surface of said tunnel magnetoresistance device, said insulating film and said
25 first wiring along the first direction,

a second sidewall made of an insulating material is formed on said first sidewall so as to cover each side surface of said first ferromagnetic layer, said insulating film and said first wiring along the
30 first direction, and

said first sidewall and said second sidewall are covered with a second high-permeability material layer.

35 4. The nonvolatile magnetic memory device according to claim 1, in which said first wiring comprises a first high-permeability material layer and

said electrically conductive layer which are positioned in this order from below,

- a first sidewall made of an insulating material is formed on each side surface of said first
5 ferromagnetic layer, said insulating film and said first wiring along the first direction,

a second sidewall made of an insulating material is formed on said first sidewall so as to cover each side surface of said tunnel magnetoresistance
10 device, said insulating film and said first wiring along the first direction, and
said second sidewall is covered with a second high-permeability material layer.

- 15 5. The nonvolatile magnetic memory device according to claim 1, in which said first wiring comprises a first high-permeability material layer and said electrically conductive layer which are positioned in this order from below,

20 a sidewall made of an insulating material is formed on the side surface of said tunnel magnetoresistance device along the first direction, and
said sidewall and each side surface of said insulating film and said first wiring are covered with a
25 second high-permeability material layer.

6. A manufacturing method of a nonvolatile magnetic memory device comprising the steps of;
(a) forming a transistor for selection in a
30 semiconductor substrate,
(b) forming a lower insulating interlayer on the entire surface,
(c) forming a first opening portion through the lower insulating interlayer, and forming a first
35 connecting hole connected to the transistor for selection in said first opening portion,
(d) forming an electrically conductive layer

and an insulating film on the lower insulating interlayer,

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 - (e) forming a second opening portion at least through portions of the insulating film and the electrically conductive layer which portions are positioned above the first connecting hole, and forming a second connecting hole electrically insulated from the electrically conductive layer and connected to the first connecting hole in said second opening portion,
 - (f) forming a stacking structure on the insulating film, said stacking structure being formed of at least a first ferromagnetic layer electrically connected to the second connecting hole, a tunnel barrier and a second ferromagnetic layer,
 - (g) patterning the stacking structure, the insulating film and the electrically conductive layer in the form of a stripe extending in a first direction, and thereby obtaining a first wiring comprising the electrically conductive layer and extending in the first direction,
 - (h) selectively removing the stacking structure patterned in the form of a stripe, and thereby forming a tunnel magnetoresistance device having the tunnel barrier sandwiched between the first and second ferromagnetic layers,
 - (i) forming an upper insulating interlayer on the entire surface, and
 - (j) forming a second wiring on the upper insulating interlayer, said second wiring being electrically connected to the second ferromagnetic layer and extending in a second direction different from the first direction.
7. A manufacturing method of a nonvolatile magnetic memory device comprising the steps of;
- (a) forming a transistor for selection in a semiconductor substrate,

- (b) forming a lower insulating interlayer on the entire surface,
- (c) forming a first opening portion through the lower insulating interlayer, and forming a first
- 5 connecting hole connected to the transistor for selection in said first opening portion,
- (d) forming a first high-permeability material layer, an electrically conductive layer and an insulating film on the lower insulating interlayer,
- 10 (e) forming a second opening portion at least through portions of the insulating film, the electrically conductive layer and the first high-permeability material layer which portions are positioned above the first connecting hole, and forming
- 15 a second connecting hole electrically insulated from the electrically conductive layer and connected to the first connecting hole in said second opening portion,
- (f) forming a stacking structure on the insulating film, said stacking structure being formed of
- 20 at least a first ferromagnetic layer electrically connected to the second connecting hole, a tunnel barrier and a second ferromagnetic layer,
- (g) patterning the stacking structure, the insulating film, the electrically conductive layer and
- 25 the first high-permeability material layer in the form of a stripe extending in a first direction, and thereby obtaining a first wiring comprising the electrically conductive layer and the first high-permeability material layer and extending in the first direction,
- 30 (h) forming a sidewall on each side surface of the stacking structure, the insulating film, the electrically conductive layer and the first high-permeability material layer,
- (i) forming a second high-permeability material
- 35 layer on the sidewall,
- (j) selectively removing the stacking structure patterned in the form of a stripe and the sidewalls, and

thereby forming a tunnel magnetoresistance device having the tunnel barrier sandwiched between the first and second ferromagnetic layers,

- 5 (k) forming an upper insulating interlayer on the entire surface, and

10 (l) forming a second wiring on the upper insulating interlayer, said second wiring being electrically connected to the second ferromagnetic layer and extending in a second direction different from the first direction.

8. The manufacturing method of a nonvolatile magnetic memory device according to claim 7, in which the sidewall has a stacking structure of a first 15 sidewall and a second sidewall,

20 and in the step (h), the first sidewall is formed so as to cover each side surface of the stacking structure, the insulating film, the electrically conductive layer and the first high-permeability material layer, and then, the second sidewall is formed on the first sidewall so as to cover each side surface of the first ferromagnetic layer, the insulating film, the electrically conductive layer and the first high-permeability material layer.

25 9. The manufacturing method of a nonvolatile magnetic memory device according to claim 7, in which the sidewall has a stacking structure of a first sidewall and a second sidewall,

30 and in the step (h), the first sidewall is formed so as to cover each side surface of the first ferromagnetic layer, the insulating film, the electrically conductive layer and the first high-permeability material layer, and then, the second 35 sidewall is formed on the first sidewall so as to cover each side surface of the stacking structure, the insulating film, the electrically conductive layer and

the first high-permeability material layer.

10. A manufacturing method of a nonvolatile magnetic memory device comprising the steps of;
 - 5 (a) forming a transistor for selection in a semiconductor substrate,
 - (b) forming a lower insulating interlayer on the entire surface,
 - (c) forming a first opening portion through the 10 lower insulating interlayer, and forming a first connecting hole connected to the transistor for selection in said first opening portion,
 - (d) forming a first high-permeability material layer, an electrically conductive layer and an 15 insulating film on the lower insulating interlayer,
 - (e) forming a second opening portion through at least portions of the insulating film, the electrically conductive layer and the first high-permeability material layer which portions are positioned above the 20 first connecting hole, and forming a second connecting hole electrically insulated from the electrically conductive layer and connected to the first connecting hole in said second opening portion,
 - (f) forming a stacking structure on the 25 insulating film, said stacking structure being formed of at least a first ferromagnetic layer electrically connected to the second connecting hole, a tunnel barrier and a second ferromagnetic layer,
 - (g) patterning the stacking structure in the 30 form of a stripe extending in a first direction,
 - (h) forming a sidewall on each side surface of the stacking structure,
 - (i) patterning the insulating film, the 35 electrically conductive layer and the first high-permeability material layer in the form of a stripe extending in the first direction with using the stacking structure and the sidewalls as a mask, and thereby

obtaining a first wiring which comprises the electrically conductive layer and the first high-permeability material layer and extends in the first direction,

- 5 (j) forming a second high-permeability material layer on the sidewall and on each side surface of the insulating film, the electrically conductive layer and the first high-permeability material layer,
- 10 (k) selectively removing the stacking structure patterned in the form of a stripe and the sidewalls, and thereby forming a tunnel magnetoresistance device having the tunnel barrier sandwiched between the first and second ferromagnetic layers,
- 15 (l) forming an upper insulating interlayer on the entire surface, and
- 20 (m) forming a second wiring on the upper insulating interlayer, said second wiring being connected to the second ferromagnetic layer and extending in a second direction different from the first direction.

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